ICC Energy Storage Program Workshop

January 27, 2022

GTI has an 80-Year History of Turning Raw Technology into Practical Energy Solutions

World-class piloting facilities headquartered in Chicago area

400+ EMPLOYEES

Collaborative Organizations and Programs

Working with utilities to address critical challenges

- OTD Operations Technology Development
- UTD Utilization Technology Development
- ETP Emerging Technology Program
- LCRI Low-Carbon Resources Initiative

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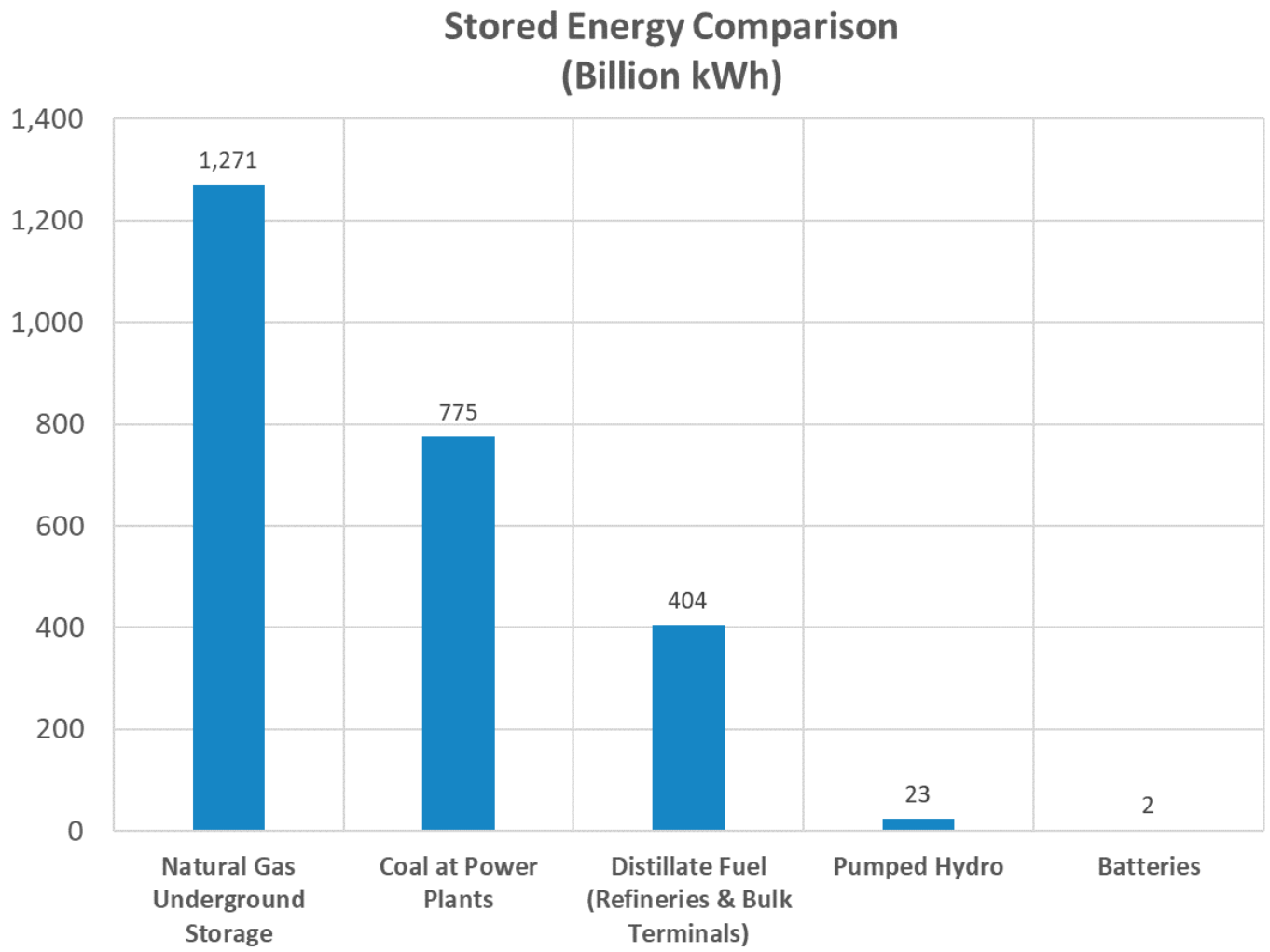
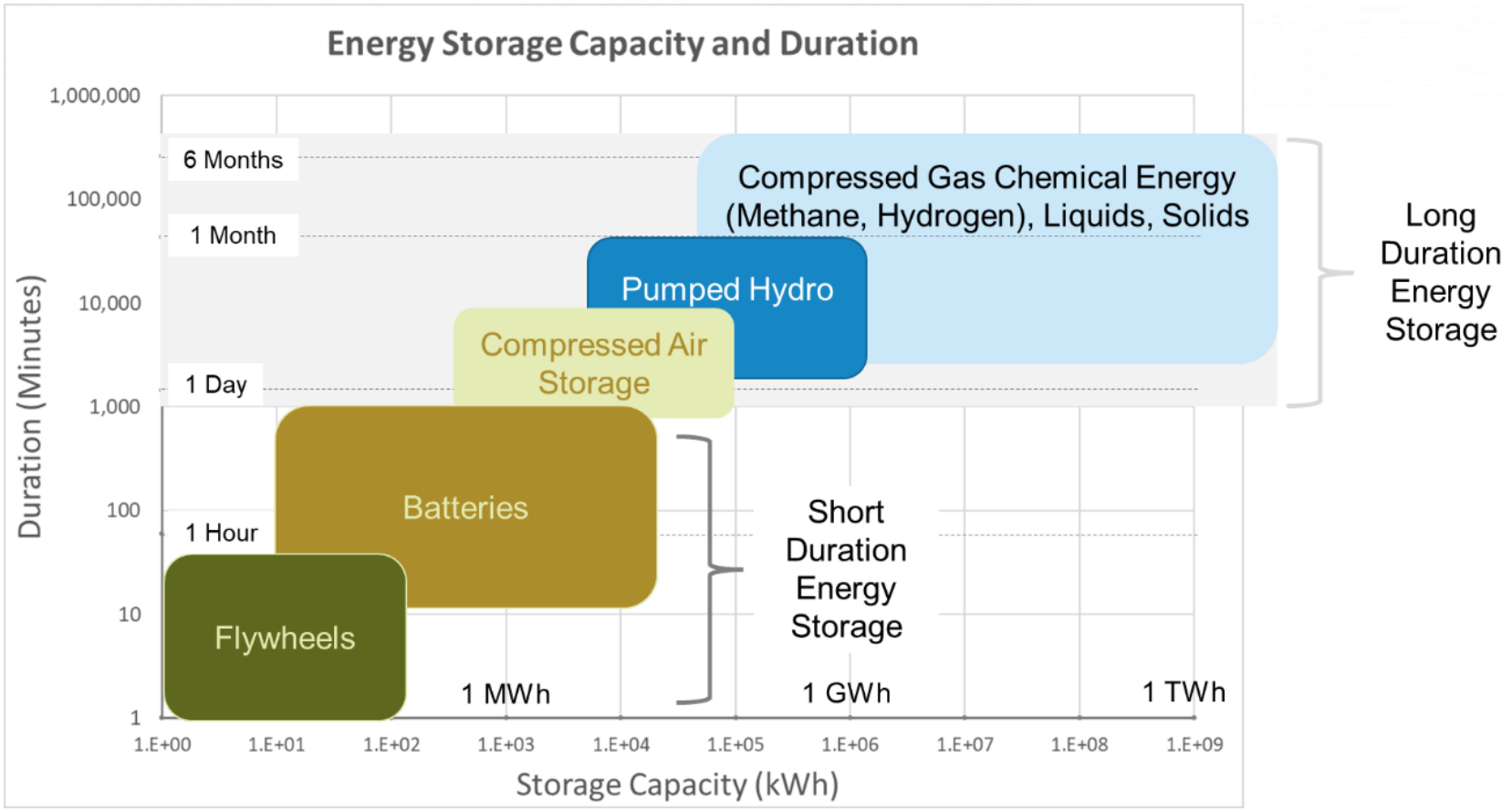
Energy Storage Options – U.S. Capacities



- Many energy storage options currently used in today's energy market
- Different forms suited for different uses
  - Electricity
  - Chemical energy carriers

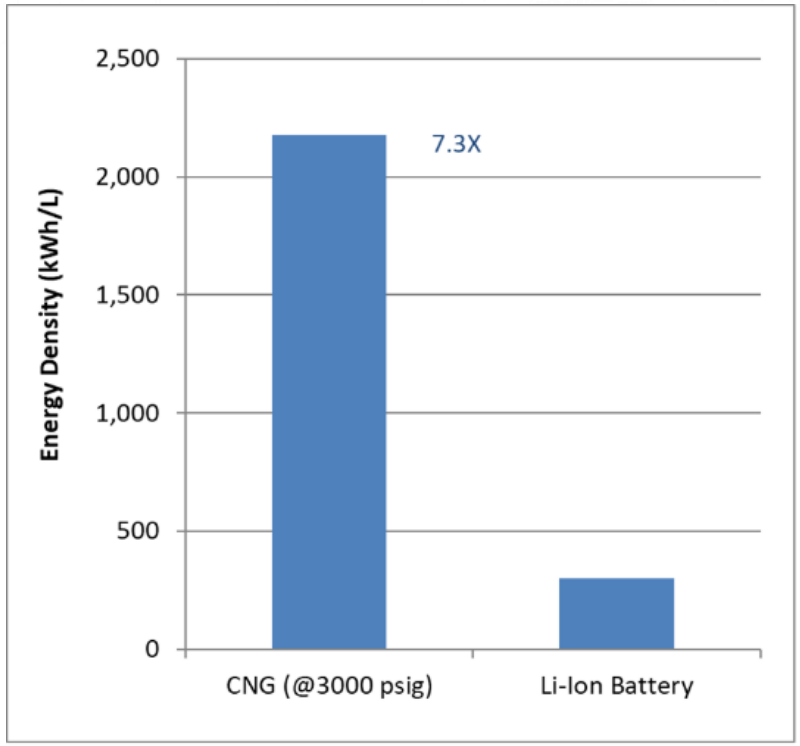
Source: DOE-EIA

Energy Storage Segments: Short and Long-Duration

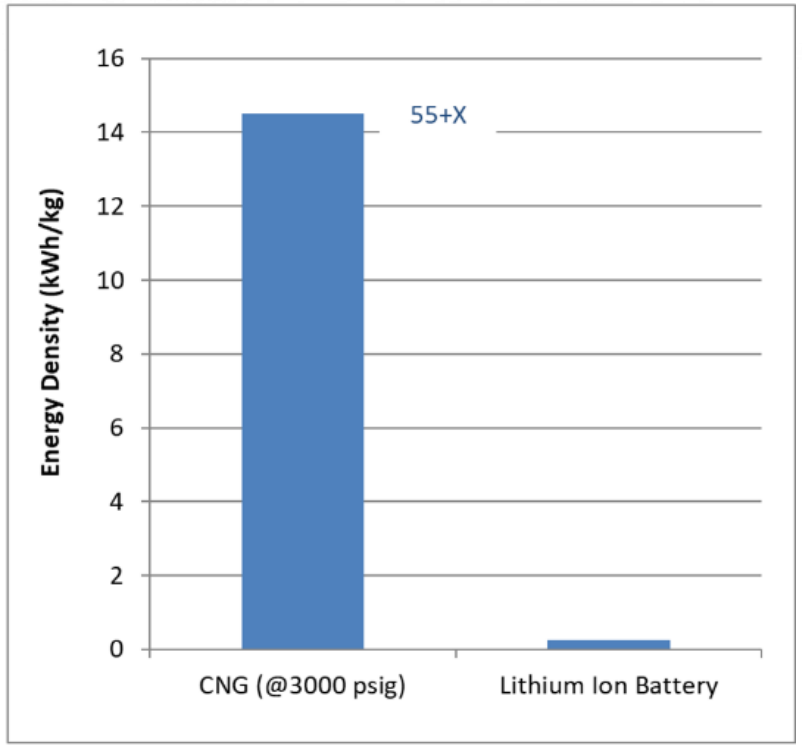


- Regulated utilities use 3 primary forms of storage for heat and power needs:
  - Pumped hydro
  - Battery energy storage systems
  - Underground natural gas storage
- Main driver is addressing periods of peak demand
  - Short duration: batteries
  - Long duration: pumped hydro, underground gas

Energy Density of Chemical and Electrical Energy Storage



VOLUMETRIC BASIS



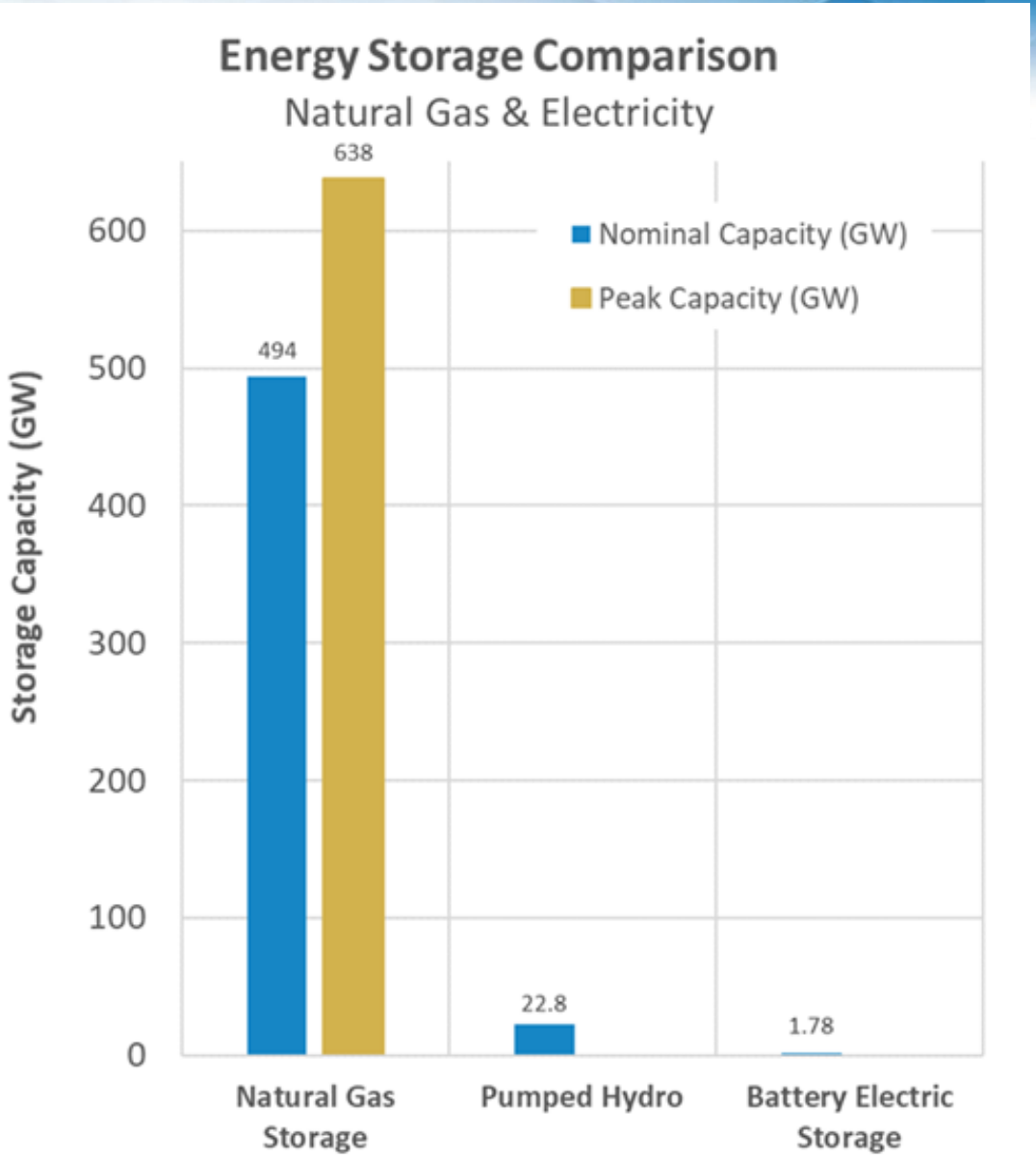
WEIGHT BASIS

- Chemical energy systems are lighter and smaller than electrochemical energy storage systems
- Translates into lower costs and reduced size

Source: DOE-EIA

U.S. Utility Energy Storage Comparison

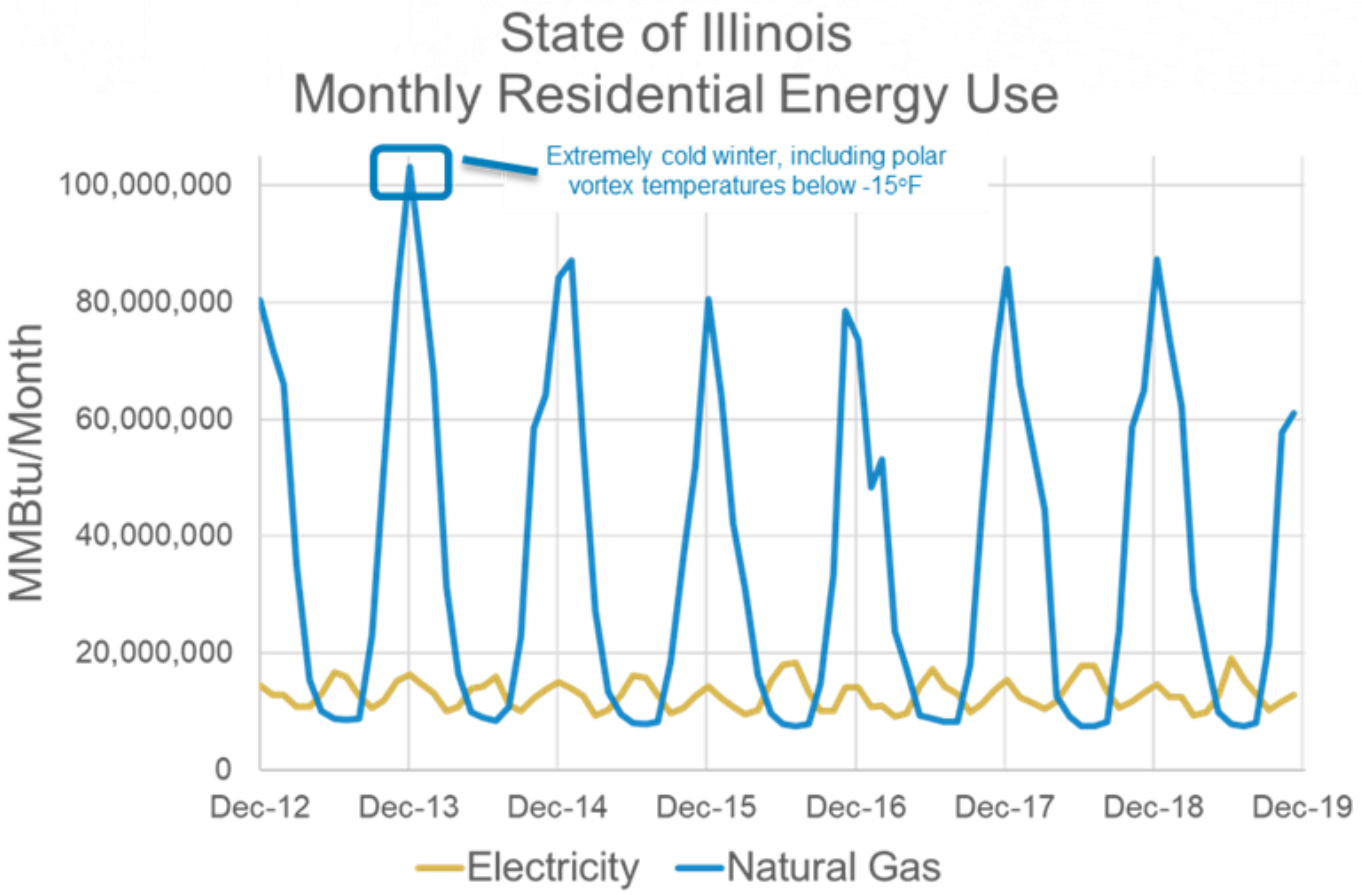
Energy Storage System	Under-ground Gas Storage*	Pumped Hydro Energy Storage	Battery Energy Storage
Nominal Capacity (GW)	495	23	1.8
Peak Monthly Energy Delivered, GWh	331,800	2900	52
Cycle Efficiency (Losses) (%)	98.8% (1.2%)	79% (21%)	82% (18%)



**Underground gas storage values stated in thermal equivalents to electric GW or GWh.*

Source: DOE-EIA

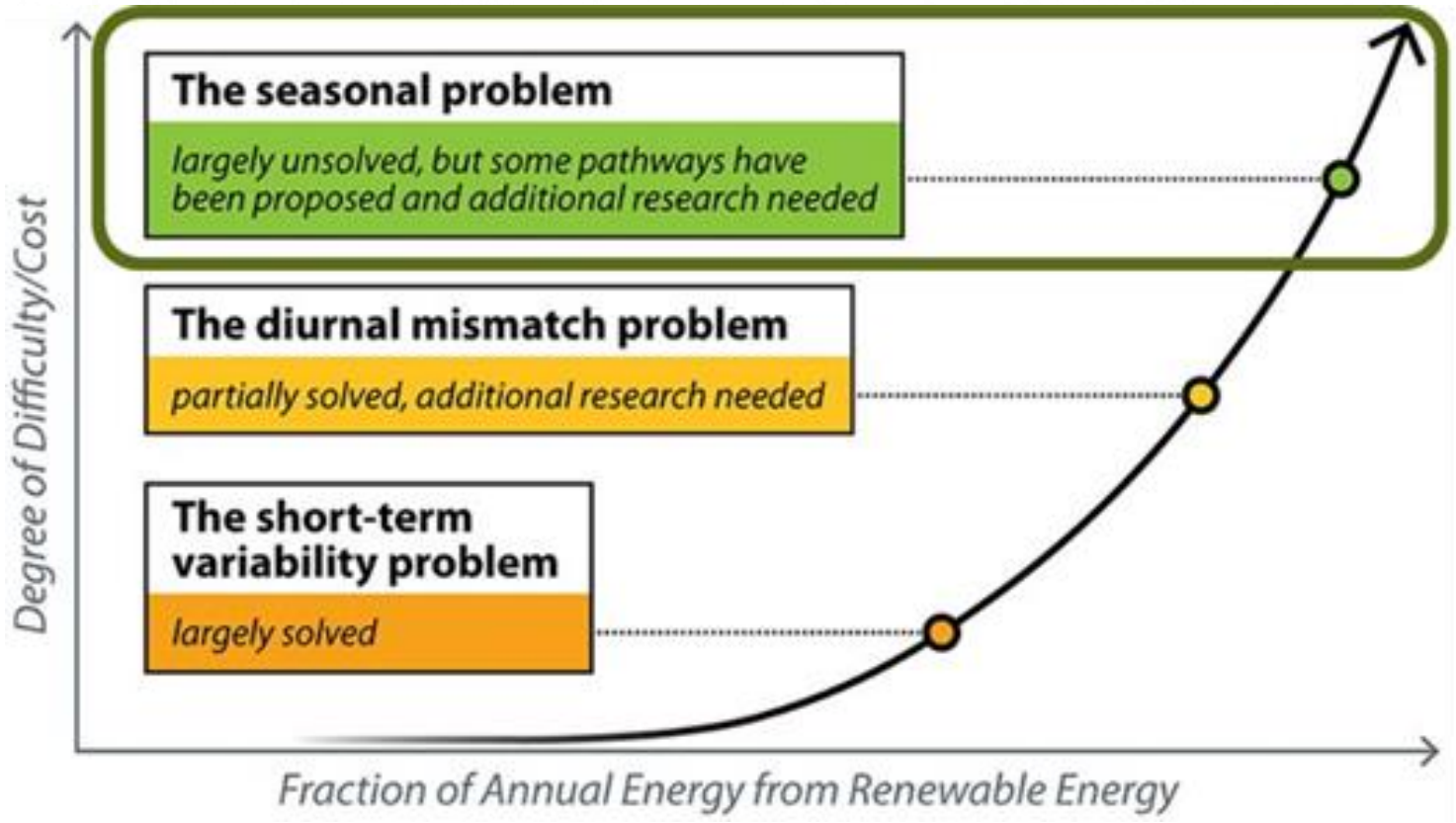
Monthly Illinois Residential Electricity and Natural Gas Use



- Long-duration energy storage systems needed to manage seasonal energy demand
  - Space conditioning for homes and buildings
  - Needed over several months in winter
- Energy needed for space heating in winter much larger than summer cooling

Source: DOE-EIA

Seasonal Generation and Energy Storage Challenge (NREL)

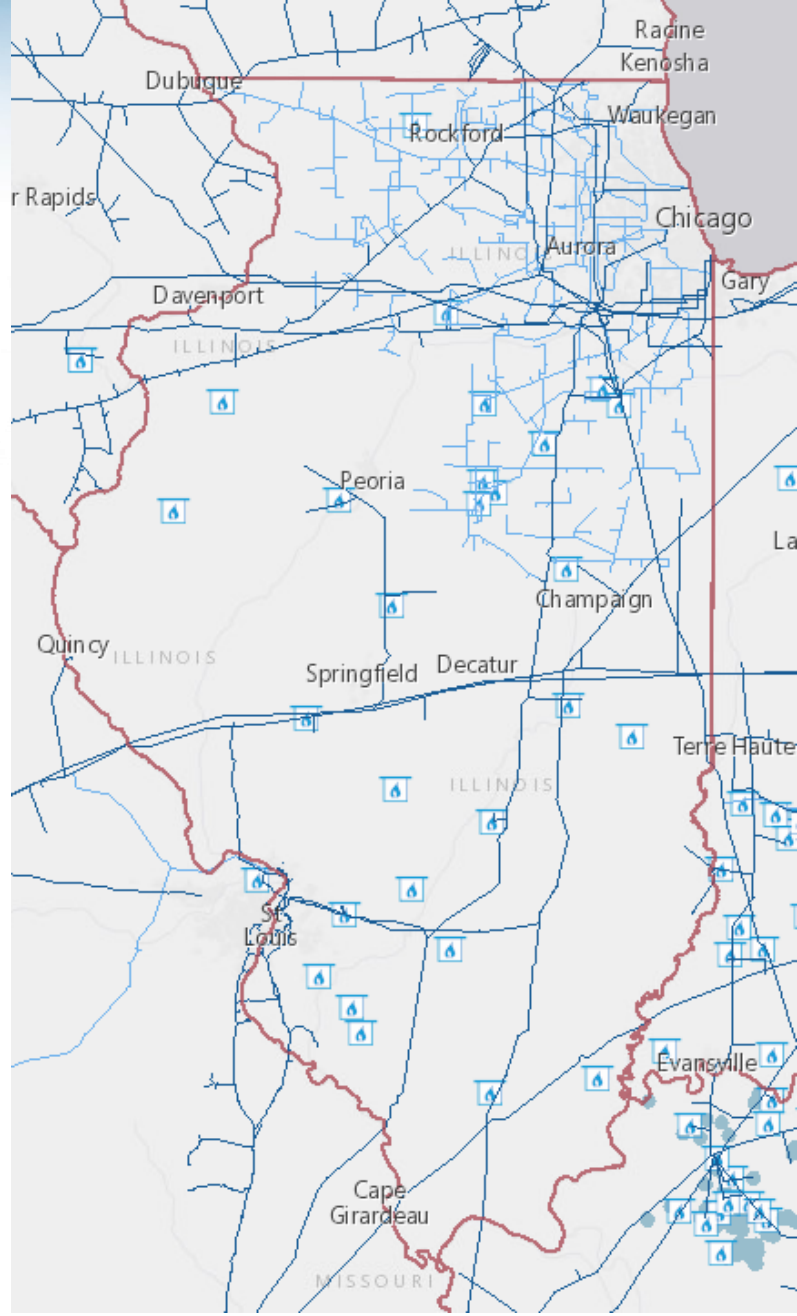


- *"Seasonal generation and demand challenges are the most difficult, most costly, and largely unresolved issue with renewable energy"*
- Duration of Illinois winter peak space conditioning is > 5 months
  - Routinely met with underground gas storage
  - Batteries well positioned for short-term energy storage

Source: NREL

Illinois Gas Storage Locations

- Illinois has geological formations which have a proven track record as safe underground gas storage facilities.
  - Illinois has 28 underground natural gas storage fields with a total storage capacity just over 1 trillion cubic feet of natural gas (DOE-EIA)
  - More than one-tenth of U.S. total natural gas underground storage capacity.
  - Working capacity of underground natural gas storage is 303 Bcf
- Underground gas storage represents a major strategic asset to the State of Illinois and its energy consumers



Source: EIA U.S. Energy Mapping System

Decarbonization of Energy Carriers and Energy Storage

- **Renewable natural gas** (RNG) from bio-energy sources as supplements or replacements for conventional natural gas
  - Includes wastewater treatment plants, landfills, agricultural or other purpose-built digesters
- **Carbon capture and sequestration** (CCS) at natural gas power plants using combination of pipeline natural gas and underground gas storage
- **Renewable or low-carbon hydrogen** (H_2) generated from wind, solar, nuclear, or natural gas reformers with CCS.
- **Compressed air energy storage** (CAES) plants, with energy from wind, solar, nuclear, or combustion turbines using renewable gas and/or CCS.

Zero-Carbon Power & Hydrogen for Illinois' Energy Future

ZERO CARBON POWER • CLEAN HYDROGEN PRODUCTION • UTILIZING LOCAL GEOLOGY

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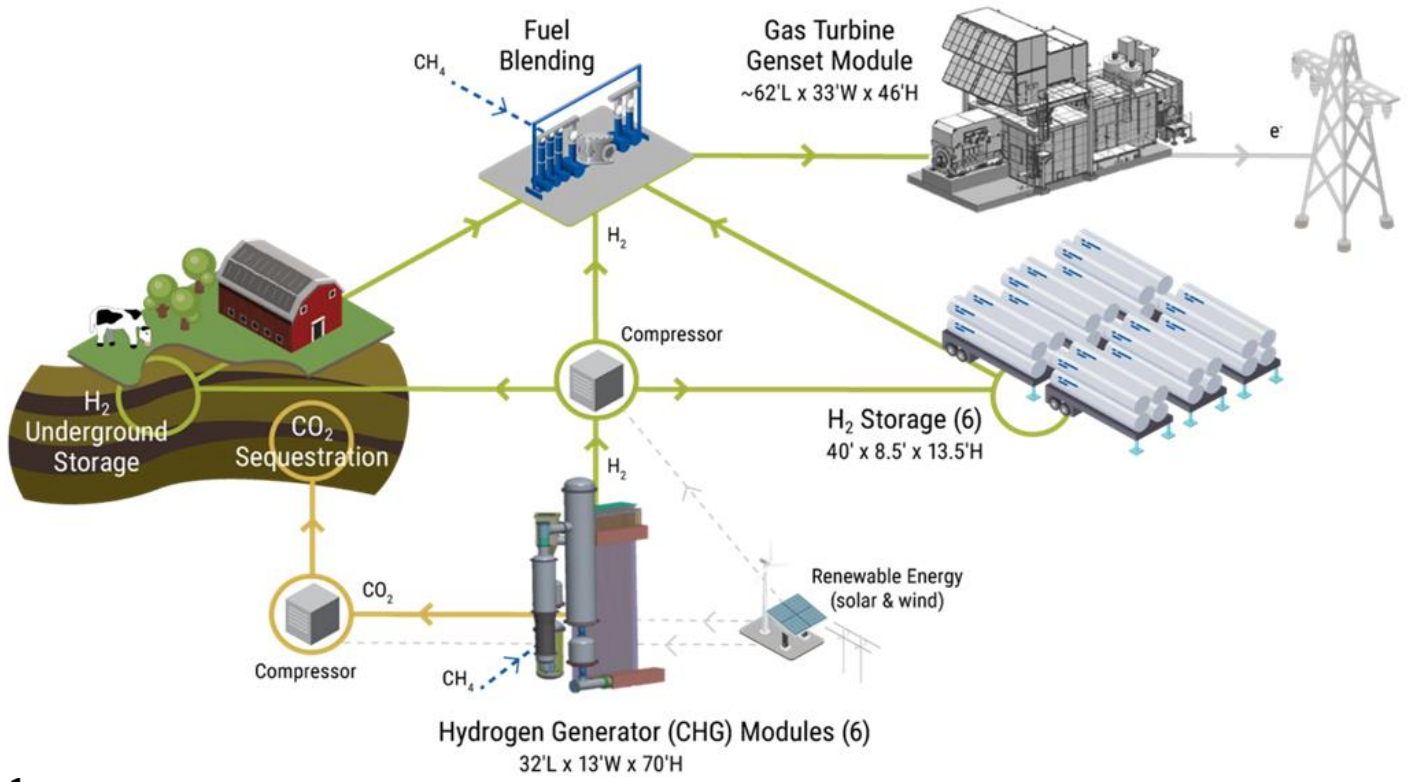

- Research, Development, and Demonstration (RD&D) key to development of clean energy carriers and energy storage systems
- Example: GTI's DOE-funded demonstration project in Illinois
  - Low-carbon hydrogen production
  - CO2 sequestration
  - Hydrogen storage
  - Dispatchable power generation

Conclusions

- Compressed gas energy storage systems are a leading, highly efficient, large-scale energy storage solution in today's market
- Illinois energy consumers – both natural gas and electric users – benefit today from the tremendous underground gas storage facilities located within the State of Illinois.
- As the state progresses in formulating a strategic focus on energy storage, it is vital the framework be technology neutral and inclusive

Turning Raw Technology into Practical Solutions